



# Australian Firearm Related Deaths: New Findings and Implications for Crime Prevention and Health Policies following revisions to Official Death Count Data

Jeanine Baker<sup>1</sup> & Samara McPhedran<sup>2</sup>

International Coalition for Women in Shooting and Hunting (WiSH), Australia

## Abstract

*Legislative interventions to address firearms misuse have received international attention in both crime prevention and public health and safety discourse. In 1996, Australian firearms legislation was tightened significantly, providing a 'natural experimental design'. Since that time, a series of studies have evaluated impacts of the legislative changes, with varying results. However, additional years of data have become available and official death count data have been substantially revised since those studies were published. The current study considered whether these new data may lead to novel findings and insights, relative to earlier studies. Time series analyses were used to evaluate firearm and non-firearm deaths. Observed and predicted firearm homicide trends did not differ significantly post-legislative reforms, while firearm suicide, non-firearm suicide and non-firearm homicide were all significantly lower than predicted. Broader social, cultural, and economic factors may have influenced both firearm and non-firearm injury in Australia. This has implications for crime prevention and public health and safety policies internationally.*

Keywords: Firearms, Injury, Safety, Homicide, Suicide.

## Introduction

Reducing levels of intentional injury, particularly lethal injury such as homicide and suicide, remains an ongoing goal internationally within the sphere of crime prevention and public health and safety policy and practice. Firearms misuse, and the possible application of legislative interventions to address misuse, has received particular attention. However, despite its international relevance, the majority of study in this field comes from the United States (see Makarios & Pratt, 2012, for an overview). Relatively little research has evaluated the impacts of significant epochs of regulatory reform upon firearm-related deaths in countries like Australia, where strict firearms regulations were introduced in

<sup>1</sup> International Coalition for Women in Shooting and Hunting (WiSH), PO Box 393, Glebe, New South Wales, 2037, Australia. Email: research@ic-wish.org

<sup>2</sup> International Coalition for Women in Shooting and Hunting (WiSH), PO Box 393, Glebe, New South Wales, 2037, Australia. Email: research@ic-wish.org

1996, following a mass shooting event. The imposition of a sweeping and nation-wide set of changes at a defined time period provides a 'natural experimental design' which enables pre- and post-reform comparisons to be made, to elucidate any effects of legislative change on firearm-related deaths.

Australia's 1996 National Firearms Agreement (NFA) prohibited semi-automatic rifles and semi-automatic and pump action shotguns. Over 600 000 firearms were confiscated and subsequently destroyed by police, at an estimated cost of around half a billion dollars (Baker & McPhedran, 2007). The NFA also introduced strict requirements governing the possession of firearms, such as the necessity to have a proven or 'genuine reason' for firearm ownership (self defence was explicitly excluded), compulsory written safety tests, and the stipulation that all privately owned firearms must be registered through a State-controlled firearms management agency. Additional components such as safe storage of firearms when not in use, and 28-day waiting periods for acquisitions of firearms were included in the reforms.

It was expected that these legislative changes would affect both firearm suicides and firearm homicides. Within suicide research, for example, there is a body of evidence that restricting access to particular suicide methods can be an effective way to reduce suicides using that particular method (see Mann et. al, 2005, for a useful overview). Consequently, it would be reasonable to anticipate that placing increased restrictions upon firearms access would lead to declines in the use of firearms as a suicide method. In terms of firearm homicide, while it was acknowledged that there was at that time, in Australia, no available data in relation to circumstances associated with firearm homicide such as whether or not a perpetrator was legally permitted to own a firearm, it was also assumed that there was a meaningful association between levels of legal firearms ownership and firearm homicide (National Committee on Violence, 1990), such that increasing the restrictions around legal firearms ownership would be reasonably expected to have impact on firearm homicides.

In recent years, a succession of studies from different research groups, using a variety of different time series and analytical methods, have considered whether there is evidence that the legislative changes had significant impacts on firearm-related deaths. Although the total number of published peer-reviewed studies based on time series data remains relatively small (fewer than 15 studies, at the time of writing), none of these studies has found a significant impact of the Australian legislative changes on the pre-existing downward trend in firearm homicide (e.g., Baker & McPhedran, 2007; Chapman, Alpers, Agho, & Jones, 2006; Lee & Suardi, 2010; Leigh & Neill, 2010; Ozanne-Smith, Ashby, Newstead, Stathakis, & Clapperton, 2004). Findings for impacts of the legislative changes on pre-existing downwards trends in firearm suicide are inconsistent. Some studies find evidence of an impact (e.g., Baker & McPhedran, 2007; Ozanne-Smith et al, 2004), while others find little or no evidence of an impact and/or document substitution to other methods (e.g., Klieve, Barnes & De Leo, 2009; Lee & Suardi, 2010; McPhedran & Baker, 2012). Understanding the exact nature of interaction between legislative change and firearm-related suicide deaths in Australia remains a challenge, given that suicides across the board (irrespective of method) have declined steadily since 1997 (Australian Bureau of Statistics, 2001; Australian Bureau of Statistics, 2007; Australian Bureau of Statistics, 2012). These declines coincided with concerted national efforts to address suicide in Australia, which included implementation of a wide range of suicide prevention strategies.

Given the often contentious nature of debate around firearms control, it is crucial to regularly update the evidence base as new data become available, to consolidate epidemiological information and more fully elucidate the nature of any changes in firearm related deaths over time. It should also be noted that, in response to concerns about the accuracy of official death count data (De Leo, 2007), primarily for the years 2006 onwards, the Australian Bureau of Statistics has issued revised counts of both suicides and assault related deaths (that is, homicides) for the years 2006–2010 inclusive (Australian Bureau of Statistics, 2012), resulting in an increased number of suicide (Sveticic, McPhedran, & De Leo, 2013) and assault related death counts (Australian Bureau of Statistics, 2012), relative to the originally published death count data. This data handling issue highlights the need to re-examine rates of firearm and non-firearm deaths using the most lengthy and accurate available post-1996 data, to assess whether the use of these new data substantively alters any previous observations about pre- and post-1996 trends in deaths.

The current paper therefore examines firearm and non-firearm suicide and homicide in Australia, using 14 years of post-legislative reform data (the maximum number of years of post-reform data at the time of writing). It specifically seeks to understand, using the most accurate available data about the number of firearm-related deaths in Australia, the nature of the post-1996 trends in firearm suicide and firearm homicide, and whether those trends differ from pre-1996 trends.

## Methods

Publicly available death count data were obtained from the Australian Bureau of Statistics. Figures were standardised to rates per 100 000 population. Although the emphasis was on firearm homicides and suicide, trends in homicide (non firearm) and suicide (non firearm) were also examined, to provide a more comprehensive picture of trends in deaths.

The data for selected sudden death categories were analysed as a time series for the period 1979 to 1996, in keeping with earlier studies (e.g., Baker & McPhedran, 2007; Chapman et al, 2006). AutoRegressive Integrated Moving Average (ARIMA) modelling was used. The ARIMA model, a flexible and commonly used method of time series analysis commonly used by the Australian Bureau of Statistics to forecast time series data (ABS, 2013), allows the future values of the time series to be estimated by a linear combination of past values and a series of errors and uses a maximum likelihood fit of the specified ARIMA model to the time series. This provided the opportunity to describe and predict the evolution of the time series from 1997 to the year 2010, noting that forecasted homicide and suicide predictions become more uncertain as time elapses. Confidence intervals were set at 95% with the model parameters selected based on examination of AIC and BIC values (Brockwell & Davis, 1991). Stability of ARIMA models was evaluated based on the partial autocorrelation charts, residual values and the  $R^2$  values.

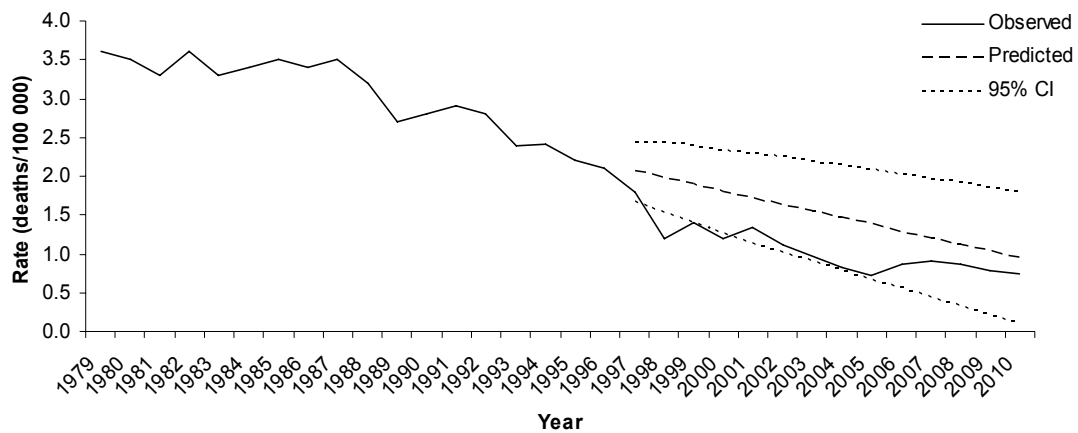
ARIMA analysis was undertaken on a subset of the data (1979 to 1996) and used to forecast rates per annum for selected sudden death categories for the years 1997 to 2010 and estimate 95% confidence limits around the predicted values. Matched pairs were used to compare the observed and predicted values for the time period 1997 to 2010.

## Results

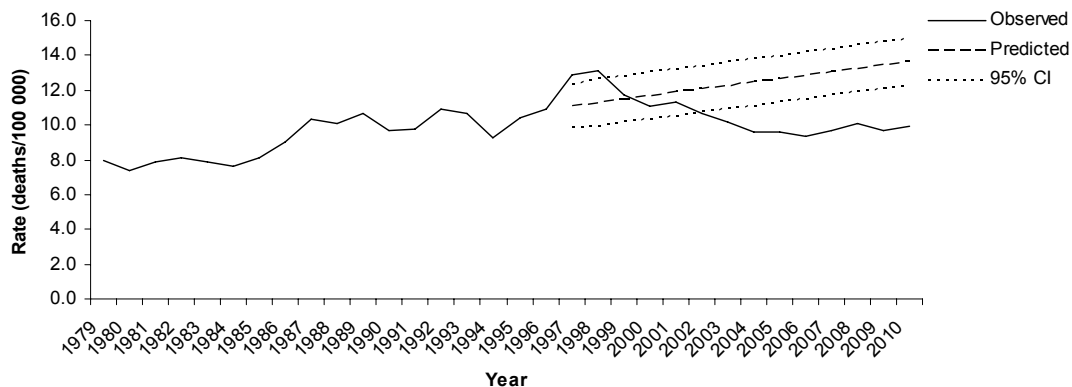
Firearm suicide rates for 1979 to 1996 were predicted well by the ARIMA (2,1,1) model ( $R^2 = 0.84$ ). Suicide rates by firearm pre- and post-NFA both showed decline, but the observed suicide rates post-NFA were consistently lower than the predicted values (Figure 1A). The paired t-test comparing predicted firearm suicide values with the observed values for the years 1997 to 2010 indicated the predicted mean firearm suicide rate was significantly higher than the observed mean firearm suicide rate ( $\mu_{\text{pred}} = 1.50$ ,  $\mu_{\text{obs}} = 1.05$ ,  $p < 0.01$ ). Interestingly, it appears that rates for the years where official records of suicide data have been revised (2006 onwards) more closely align with predicted values than years for which figures have not been revised; given that the years 2009 and 2010 have yet to undergo further revision (Australian Bureau of Statistics, 2012), the results of future analyses of firearm suicides may differ from the current (and former) analyses undertaken.

Figure 1: Firearm (A) and non-firearm suicide (B) rates, observed and predicted values

A



B



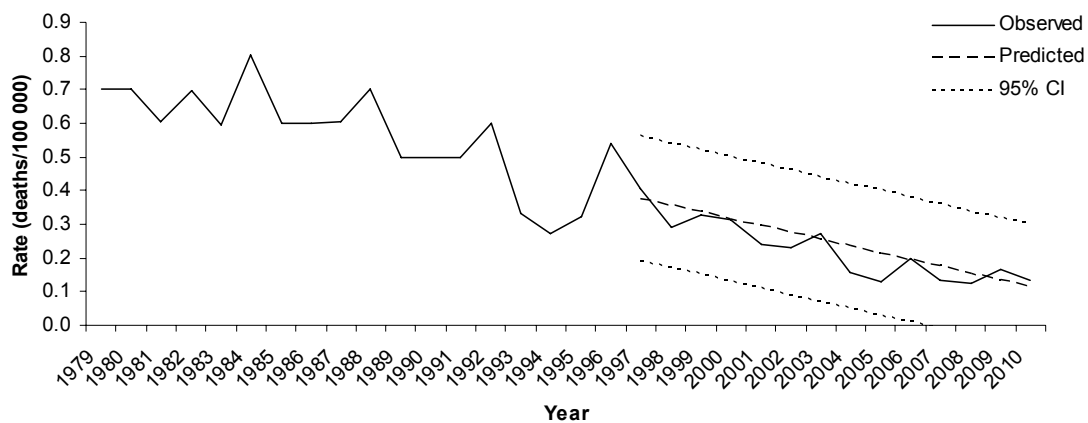
Pre-NFA, suicide (non firearm) rates were increasing (Figure 1B). The ARIMA (1,1,1) analysis predicted the 1979 to 1996 suicide (non firearm) well ( $R^2 = 0.72$ ). With the significance level set at 0.05, predicted and observed suicide (non firearm) rates post-NFA showed a significant change in non-firearm suicide ( $\mu_{pred} = 12.35$ ,  $\mu_{obs} = 10.64$ ,  $p < 0.01$ ).

The pre-existing downward trend observed for firearm homicide continued post-NFA (Figure 2A). The ARIMA (1,1,1) model did not predict firearm homicide as well as it did for firearm suicide ( $R^2 = 0.48$ ). The paired t-test comparing rates of predicted homicide by firearm with the observed rates for the years 1997 to 2010 indicated no significant difference between the two at the 0.05 significance level ( $\mu_{pred} = 0.24$ ,  $\mu_{obs} = 0.22$ ,  $p = 0.07$ ). It should be noted, however, that the relatively small number of firearm homicides in Australia each year entails interpretive caution.

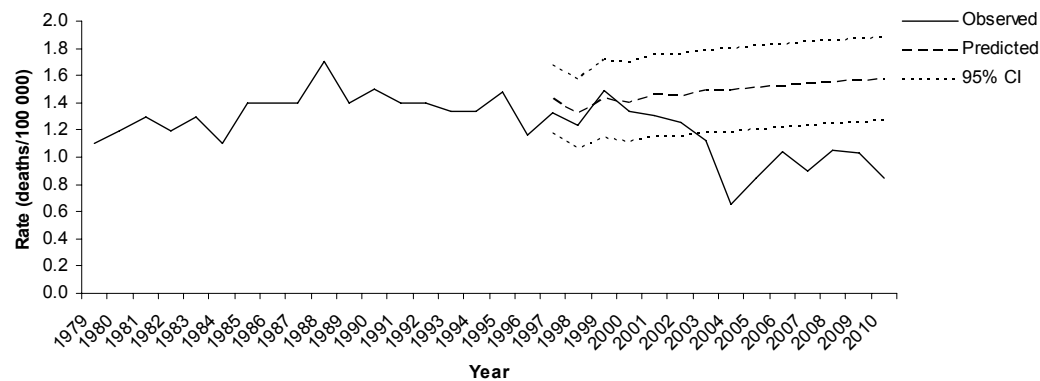
ARIMA modelling was a poor predictor for homicide (non firearm) ( $R^2 = 0.31$ ). However, based on the ARIMA (2,1,1) model, predicted homicide (non firearm) rates post-NFA and observed rates (Figure 2B) differed significantly, using the 0.05 significance level ( $\mu_{pred} = 1.48$ ,  $\mu_{obs} = 1.10$ ,  $p < 0.01$ ).

**Figure 2: Firearm (A) and non-firearm (B) homicide rates, observed and predicted values**

A



B



## **Discussion and Conclusion**

The current findings suggest that, using the most accurate available data and a longer time series than previous studies into firearm-related mortality have used, the only type of firearm-related death that may have been influenced by the introduction of the NFA was firearm suicide. However, caution must be applied to this finding in light of the significantly lower observed rates for suicide (non firearm) relative to predictions based on pre-1996 trends. While the current study contradicts some earlier findings (e.g., Baker & McPhedran, 2007), where there was limited evidence found for significant accelerations in post-1996 trends in non-firearm suicide compared with pre-1996 trends, the present results are consistent with other studies that have suggested a significant change in non-firearm suicides post-1996, relative to earlier trends (Chapman et al, 2006) .

Taken in conjunction with the suicide (firearm) rates these new findings suggest that, when the longest available post-1996 time series, using the most accurate available data, is considered, both firearm and non-firearm suicide have declined substantively over time, with significant differences in pre- and post-1996 trends irrespective of suicide method. This is an important finding, because it indicates that although data revisions have led to increased numbers of suicides recorded in official Australian death data, declines in suicides – both firearm and non-firearm – remain apparent over time.

Collectively, these two observations suggest that broader societal factors including, but not limited to, increased funding for suicide prevention strategies, improved treatments for mental illnesses, greater recognition of the complex needs of many persons at risk of suicide, cultural attitudes towards suicide, and – potentially – a period of economic prosperity may have impacted significantly on both firearm and non-firearm suicide rates. The supposition that factors such as employment levels, financial prosperity and stresses, and the availability of support networks have a marked influence on both firearm and non firearm suicide is supported by a range of other research (e.g., Duggan, 2003; Beautrais, Fergusson & Horwood 2006; Kates 1990; Kellerman et al., 1993). While noting the potential for further upwards revision of suicide data (Australian Bureau of Statistics, 2012), it is possible that programs focussing on comprehensive intervention techniques and high-risk populations, rather than specific suicide methods, may have contributed to the overall declines (Vos et al., 2011).

Observed and predicted firearm homicide trends did not differ significantly, suggesting that, in keeping with earlier work (e.g., Baker & McPhedran, 2007; Chapman et. al, 2006; Lee & Suardi, 2010), there is little evidence to indicate that existing trends in firearm homicide rates were influenced by the NFA. Interestingly, the post-1996 time series examined in this study found significant declines in observed non-firearm homicide rates, relative to predictions based on pre-1996 trends. This new finding has not been reported elsewhere in the literature, but – in similar fashion to the results for firearm and non-firearm suicide – suggests that social and economic factors in recent years (for example, a demographic shift towards an ageing population, along with low levels of unemployment) may have influenced levels of lethal violence in Australia.

Noting that the relatively small sample size associated with firearm homicides each year entails interpretive caution being applied, there are selections of possible explanations for the apparent lack of impact of the legislative changes on firearm homicide. While it was originally thought that increasing restrictions on access to firearms and criteria for obtaining a licence would lead to a significant drop in firearm related deaths, including homicide (National Committee on Violence, 1990), subsequent work has found that little

association between legal firearms ownership and firearm homicide (Davies & Mouzos, 2007; Dearden & Jones, 2008; Mouzos, 2002; Mouzos, 2003; Mouzos, 2005; Mouzos & Houliaris, 2006; Mouzos & Segrave, 2004). In addition, it was assumed that levels of firearms misuse correlate with levels of legal ownership. Although the available data are limited, Australia's most populous state (New South Wales) has experienced ongoing declines in firearm misuse in the context of ongoing increases in legal ownership (McPhedran, 2013; New South Wales Parliament, 2011). Consequently, it is possible that the legislative intervention may have targeted 'low-risk' groups (Reuter & Mouzos, 2003), rather than those at high-risk of committing violent crime.

In terms of policy implications, Australia's legislative approach had a high initial cost with the buyback program costing around \$500 million. Subsequent costs associated with administering various components of the legislation such as mandatory registration of all firearms (estimated at between \$27 and \$100 million nationally per year; Vos et al., 2011; Nous Group, 2007) are also high. In terms of cost-effectiveness, the accumulated research suggests that it may be worthwhile examining whether resources should be directed into alternative means of reducing firearms injury mortality (for example, carefully targeted programs aimed at reducing criminal activity).

However, although the current study provides useful insights into firearm-related deaths in Australia, further work is required. It would be a matter of theoretical interest, for example, to establish whether it was the use of the longer time series that generated discrepant results between the present study and past studies, or whether those discrepancies are attributable to the death count data revisions rather than the different time period studied. On face value, however, it is likely that the results in the present paper are attributable mainly to the lengthier time series used, given that ABS data revisions covered the years 2006 onwards, and that previous studies against which the present work is contrasted primarily used time series that ended before 2006.

Importantly, due to limitations in the extent to which death count data were able to be disaggregated, this work was unable to examine trends by variables such as age or location – which may reveal policy-relevant contextual information. For example, previous work (McPhedran & Baker, 2012) has suggested that the observed changes in trends in firearm suicide may apply only to certain age groups. Also, given the revision of death count data is an ongoing process, there remains open the possibility that future revisitation of these data may produce different results again. Finally, it is prudent – as with any study – to consider the possibility that the significant results observed in this particular study may arise from statistical error, given (for example) the model fit for non-firearm homicide and the inherent variability within the data.

In summary, the current paper adds to the evidence base around Australian firearms legislative impacts and shows that the use of a longer time series relative to earlier studies, which also includes the most accurate available (revised) official death count data, produces novel findings about the effects of Australia's 1996 legislation on firearm-related deaths. This study's use of a longer post-1996 time series relative to earlier studies into firearm-related deaths led to a selection of research findings that contradict some aspects of earlier studies, but which simultaneously strengthen other results generated by earlier research. The declines in both non-firearm suicide and non-firearm homicide suggested by the current study, while requiring further investigation, nonetheless raise the possibility that broader social and economic factors, as well as factors such as specifically designed 'vulnerability-oriented' suicide prevention measures and targeted policing initiatives, may

have the capacity to impact on suicide and homicide rates in general, irrespective of method/s used. This has implications for the design and implementation of crime prevention and injury prevention policy development internationally.

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